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MATERIALS SCIENCE AND METALLURGY

No. 73

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USSR REPORT

MATERIALS SCIENCE AND METALLURGY

No. 73

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WELDING

MISCELLANEOUS

UDC: 669.715.017:629.17

INFLUENCE OF REM ON THE MECHANICAL PROPERTIES OF THE ALLOY Al+6.5% Mg

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 10, Oct 80 pp 35-37

DRITS, M. Ye., TOROPOVA, L. S. and BYKOV, Yu. G., Institute of Metallurgy imeni A. A. Baykov

[Abstract] A study was made of the influence of elements of subgroup IIIA (scandium, yttrium, and lanthanum) and the rare earth metals (cerium, europium, gadolinium, dysprosium, terbium and holmium) on the mechanical properties of an alloy consisting of Al+6.5% Mg, the basis of the widely used AMg6 alloy. Specimens were melted in a laboratory induction furnace in an atmosphere of argon and molded in a water-cooled laboratory mold. Chemical analysis of the alloys was used to assure agreement with the desired composition. After homogenization at 430° C for 24 hours the alloys were pressed at 420° C and mechanical properties determined in extension at $1.34 \cdot 10^{-3}$ s^{-1} using five specimens of each composition, gage section 5 mm in diameter. Scandium was found to be most effective in increasing the strength by a factor of 1.5 and the yield point by a factor of 2. The relative elongation decreases to 15%. Annealing at 320° C for 1 hour has practically no effect on the mechanical properties. The remaining elements studied fall in the following order of decreasing influence on strength: dysprosium europium, cerium, gadolinium, lanthanum, yttrium, holmium, terbium. Small quantities (about 0.2%) of the alloying element are most effective in all cases. The greatest hardening is achieved by introduction of 0.5% Tb. All of the alloys except those with scandium were found to have a recrystallization structure. References 8: all Russian. [24-6508]

UDC: 669.715:621.78.063.4

INFLUENCE OF HARDENING IN NEW MEDIA ON THE PROPERTIES AND STRUCTURE OF ALUMINUM ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 10, Oct 80 pp 26-30

KONYUKHOV, G. P., BEDAREV, A. S., BELOBORODOV, G. I., IL'YUSHKO, Ye. G., MURAV'EV, V. V. and SHARKO, A. V.

[Abstract] A study is made of the influence of hardening by quenching in an aqueous solution of polyethylene oxide on the physical, mechanical, acoustical and microstructural properties of the alloys D16, V95 and AK4-1. The polyethylene oxide used was a polymer with a molecular mass of $5 \cdot 10^5$-$5 \cdot 10^6$. The study was performed on sheets 2-6 mm thick, rods 20-30 mm in diameter and plates 30 mm thick. The specimens of D16 were heated to 500±5° C, V95 - to 470±5° C and AK4-1 - to 530±5° C. The 2 mm sheets were held at this temperature for 25 minutes, the 4-6 mm sheets for 40 minutes, and rods and plates for 60 minutes. The D16 specimens were naturally aged, the V95 specimens were aged at 120° C for 3 hours plus 165° C for 3 hours, and the AK4-1 specimens were aged at 190° C for 16 and 32 hours. After heat treatment, the hardness and conductivity were measured, strength, yield point and relative elongation determined, and corrosion resistance and microstructure studied. The hardening media were aqueous solutions containing 0.1% to 2.0% PEO. PEO hardening of D16 greatly reduced the warping usually seen in water. A concentration of 0.3-1.0% PEO with a molecular mass of at least $3 \cdot 10^6$ was found to be optimal for hardening of the alloys tested. More concentrated solutions of PEO do not support complete hardening of massive specimens. Figures 3; references 6: 5 Russian, 1 Western.
[24-6508]

UDC: 669.721.71:669.883:620.17:620.18

INFLUENCE OF SODIUM ON THE STRUCTURE AND MECHANICAL PROPERTIES OF CAST Al-Mg ALLOY

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 10, Oct 80 pp 33-35

VOLKHONTSEV, I. B., VOLKHONTSEV, S. B., MUDOKSANOV, Yu. M. and SHIL'NIKOVA, L. L.

[Abstract] A study is made of the alloy Al23-1, produced in 20 kilogram graphite-chamotte crucibles in an electric resistance furnace. All specimens studied contained 6.11-6.35% Mg, 0.09-0.11% Ti, 0.15-0.20% Zr, 0.05-0.07% Be, less than 0.05% Si, less than 0.05% Fe, less than 0.01% Mn, and less than 0.05% Cu; specimens without sodium contained 360-450 mm^3 H/100 g metal, specimens with sodium 200-120 mm^3 H/100 g metal. The sodium content was varied from 0.0021 to 0.056%. Introduction of sodium caused darkening of castings from silvery white to dark gray, with an oxide crust on open portions of the castings. A sharp reduction in strength and ductility of the alloy was observed in the sodium concentration range of 0.004 to 0.0070%. With a sodium content of 0.014% or higher the alloy becomes brittle.

The sharp decrease in strength and ductility of AL23-1 is accompanied by a significant increase in density. A significant increase in the quantity and dimensions of β phase particles was observed throughout the range of sodium content studied. The tendency to formation of hot cracks is also greatly increased, a result of the presence of a liquid film on the grain boundaries in the final stage of crystallization. Figures 1.
[24-6508]

UDC 621.785.5:669.781.8

VACUUM INVESTIGATION OF THE FRICTIONAL PROPERTIES OF 12KH18N10T STEEL WITH BORIDE COATINGS AT HIGH TEMPERATURES

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian No 6, Nov-Dec 80 pp 30-33 manuscript received 7 Aug 79

BORISOVA, A. L., GURVICH, O. S., MINKOV, O. B., BRAUN, S. M., MARTSENYUK, I. S. and KAPLINA, G. S., Institute of Problems of Material Sciences, Ukrainian SSR Academy of Sciences, Kiev, and All-Union Scientific Research Institute of Electrothermal Equipment, Moscow

[Abstract] The frictional properties of 12Kh18N10T steel with boride coatings were determined during operation of the frictional assembly at high temperatures. The austenitic steels were first plated with iron to enhance the boriding properties of the specimens. The tendency of steel to seizure is reduced significantly if the specimens are first plated with iron prior to boriding compared to pure boriding. The frictional drag coefficient of borided and annealed steel remains insignificant at 700°C in a vacuum. The drag coefficient increases significantly for unannealed steel. Wear intensity is also greater on the boride layer in an unannealed specimen than that in an annealed specimen. A boride coating up to 50 microns thick can be achieved on steel that is first plated with iron, thus reducing the tendency of steel to seizure at high temperatures in a vacuum. Figures 5; references 6: 5 Russian, 1 Western.
[30-6521]

UDC: 669-494

INFLUENCE OF A PROTECTIVE COATING OF ZIRCONIUM CARBIDE ON THE INTERACTION OF FIBERS OF SILICON CARBIDE WITH A MATRIX OF COMPLEXLY ALLOYED NICKEL

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 5, Sep-Oct 80 pp 156-159 manuscript received 6 Oct 77

IVANOV, V. K., KUT'YENKOV, V. A., SHULEPOV, V. I., GUZEY, L. S., SOKOLOVSKAYA, Ye. M. and DOROKHOVICH, V. P., Moscow, Kiev

[Abstract] Coatings of zirconium carbide 30-40 μm thick were applied to fibers by precipitation from the gas phase. A layer of pyrocarbon was precipitated onto the fibers before application of the zirconium carbide. Specimens of the composite

material were obtained by hot vacuum pressing at 1100° C for 10-15 min. The specimens were annealed in a vacuum of $1 \cdot 10^{-4}$ mm Hg, after which they were studied metallographically and microroentgenographically. The studies showed that coatings of zirconium carbide 30-40 μm thick protect silicon carbide fibers from interaction with a matrix of ZhS6U alloy better than thin coatings of titanium nitride. Analysis indicated that the fibers of the composite material remain basically unaltered. However, the coating does interact with the components of the matrix. Titanium and niobium are concentrated primarily in the outer zone of the coating, apparently dissolving in it, while nickel, cobalt and to a lesser extent chromium are located in the zone of the coating adjacent to the intermediate layer of pyrocarbon. Chromium penetrating through the coating probably interacts with the pyrocarbon to form carbides containing some nickel and cobalt. Annealing of the specimens at 1100° C for 100 hours results in complete destruction of the fibers, with practically all of the components of the material penetrating into the volume occupied by the fibers. Figures 2; references 7: 4 Russian, 3 Western.
[25-6508]

UDC 620.197.6

THE HEAT RESISTANCE OF MULTICOMPONENT NIOBIUM ALLOY COATINGS

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian No 6, Nov-Dec 80 pp 27-30
manuscript received 24 Dec 79

MAKSIMOVICH, G. G., PAVLINA, V. S., STAKHNYAK, B. N. and VENGRENOVICH, R. D.,
Physico-Mechanical Institute, Ukrainian SSR Academy of Sciences, L'vov

[Abstract] The thermal stability of niobium and its alloys was tested metallographically after being aged in air at high temperatures. The specimens were subjected to diffusion saturation with aluminum together with chromium and silicon, which reduce mobility. Sodium, lithium, bismuth and lead melts were used to saturate them with chromium, aluminum and sodium. Saturation of niobium alloys with the given elements produces a thin transition layer between the matrix and coating. The microhardness of this layer is lower than that of remaining layers. The transition layer increases in thickness as the length and temperature of isothermal aging increase. Alloys coated with chromium, aluminum and silicon oxidize less readily and this coating protects the matrix against oxygen penetration, although it does not completely protect the alloy against oxidation. Multiple thermocycling of the specimens essentially does not alter the pattern. This indicates that the coatings are thermally stable and that they can be used to protect niobium alloys against oxidation in air at high temperatures. Figures 2; references 3: all Russian.
[30-6521]

UDC: 624.07:678.067

COMPARATIVE ESTIMATE OF THE EFFECTIVENESS OF SEVERAL TYPES OF END FITTING FOR HOLDING TUBULAR RODS OF COMPOSITE POLYMER MATERIALS

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 5, Sep-Oct 80 pp 941-943
manuscript received 25 Jun 79

KARPINOS, D. M., KADYROV, V. Kh. and KRYLOV, Yu. V., Institute of Material Science Problems, Ukrainian Academy of Sciences, Kiev

[Abstract] The purpose of this work is to select the optimal type of attachment to assure reliable connection of fiber-reinforced plastic tubes to metal end lugs and to assure the maximum load-bearing capacity of structural members operating with alternating axial loads. Adhesive, mechanical and combined types of attachment were used. Cross-sectional drawings illustrate the attachment schemes tested. A new type of attachment was also tested, utilizing the property of increased plasticity and malleability of polymer composite materials heated to 80-90% of the polymerization temperature of the binder. The metal tip was heated to 130±5° C, the heated composite tube was pressed into the metal tip at 10 to 30 kgf, the structure was then cooled, the tube removed, and cold-curing adhesive applied and reinserted. The initial hot insertion served to improve the fit between the composite tube and the metal tip, thus increasing the strength of the adhesive. A further development of this same method used a magnetic inductor through which a pulse with a power of about 15 kJ was transmitted to squeeze the tip onto the tube after heating. The new types of attachment produced greater strength and rigidity of the joint. The use of the magnetic-impulse method decreased the labor consumption of manufacture of a typical part by 25-30%. Figures 5; references 2: 1 Russian, 1 Western.
[32-6508]

UDC: 624.074:678.067

THE PROBLEM OF THE LOAD-BEARING CAPACITY OF A PRESSURE VESSEL WITH A DOUBLE WALL CONSIDERING THE EDGE EFFECT

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 5, Sep-Oct 80 pp 881-886
manuscript received 5 Feb 80

ZAYTSEV, G. P., VASILEVSKIY, V. M., KOPYL, N. I., SUD'IN, V. N. and PAZHKOV, V. A.,
Moscow Institute of Aviation Technology imeni K. E. Tsiolkovskiy

[Abstract] A study is made of double-walled pressure vessels consisting of an interior metal wall plus glass-reinforced plastic which adds little to the strength of the vessel but serves to prevent fragmentation upon failure. The purpose of the work was to determine the extent of the edge-effect zone and its influence on the stress state as functions of the geometric dimensions of the cylinder, the pressure at which the glass-reinforced plastic layer fails and the pressure at which the metal becomes plastic or fails. A BESM-6 computer was used to calculate the zone of influence of the edge effect, the stress-strain state of the glass-reinforced plastic and metal in the bottom and in the cylindrical portion of the vessel, the loss of monolithicity and failure of the glass-reinforced plastic, the transition of the metal to the plastic state and its fracture, using existing programs. The edge effect is found to have a significant influence on the distribution of shear stresses between layers, the maximum value of which is observed at the junction between the bottom and sides. At a pressure of 34 MPa, the shear stress between layers is 29.3 MPa at this point. Good adhesion between the two layers is thus required if their joint work is to be effective. Consideration of the influence of the edge effect reduces the calculated failure pressure by 4%, from 89 to 84.8 MPa. The experimentally determined failure pressure was 83 MPa. Figures 5; references 6, all Russian.
[32-6508]

UDC: 678.02:541.64:539.4

INCREASING THE FRACTURE TOUGHNESS OF HIGHLY CROSS-LINKED POLYMER MATRICES OF COMPOSITE MATERIALS

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 5, Sep-Oct 80 pp 771-776
manuscript received 7 Feb 80

TROITSKAYA, Ye. B., BABAYEVSKIY, P. G., KULIK, S. G. and STEPANOVA, M. I.,
Moscow Institute of Aviation Technology imeni K. E. Tsiolkovskiy

[Abstract] The toughness of amorphous vitreous polymers is determined to a great extent by the expenditure of energy on local plastic deformation during crack growth. The toughness of vitreous polymers can be greatly increased by the creation of heterogeneous composite matrix structures consisting of a vitreous continuous phase with a small quantity of dispersed elastic or plastic phase to initiate the formation of microscopic cracks upon local shear deformation. This effect of elastification can be achieved by the introduction of flexible-chain

oligomers of polymers. This work presents results from studies to determine the processing and effectiveness of electrification of highly cross-linked polymers by the addition of oligomer-polymerizable diacetylene which cure by various reactions. Cp-20 liquid epoxy resin and PD-63 curing agent polymerizable diacetylene were used in the study. The oligomer-polymerizable composites were vacuum treated, the required quantity of curing agent or initiator introduced, then they were poured into a mold made of sheets of epoxy glass treated with an antiadhesive and cured. Thin-sections of the fracture surfaces were obtained on a transmission electron microscope after etching. The glass structure of the cured oligomer-polymerizable compositions was found to be determined largely by the interaction of the PD epoxidizable components with the cured oligomers in the stage of PD epoxidation and by the presence of curing. The epoxy-polymerizable compositions have a clear matrix-heterogeneous structure in the cured state with bimodal distribution of phase particles by dimension. The largest dispersed particles are on the order of 0.1 μm in diameter, the smaller ones - 0.1 μm. The phase structure of the PD-63 composite is significantly different from that of the epoxy-polymerizable diacetylene. During the curing of this composite, the process of the dissolved component facilitates the formation and separation of dispersed particles of oligomer-polymerizable composite has much more clearly expressed globular structure. The mechanical properties of cured oligomer-polymerizable compositions are closely related to their phase structure, physical state, properties and the molecular state of the phases. The use of highly cross-linked epoxy matrices plasticized with PD produces a combination of high fracture toughness and strength under static and cyclical loading. Figures 6; references 11: 7 Russian, 4 Western.
[2-6108]

UDC 539.3:678.067

Determination of the effective elastic moduli of composite materials

Kiev Mekhanika kompozitnykh materialov in Russian No 6, Nov-Dec 90 pp 997-999
Manuscript received 7 Feb 90

[illegible], V. Z., Odessa Polytechnic Institute named Admiral S. O. [illegible]

[Abstract] The connection between inclusions within the framework of a self-consistent method is considered for the concentric-spherical model of composite materials. A system of expressions are derived by the variational method for effective elastic moduli of multiphase composites and covering of two-phase matrix spheres for the concentric-spherical model. The effective moduli of the composite material were determined numerically. The boundaries for the effective moduli of granulated composites are somewhat higher than those given by Hashin and Shtrikman variation and also yield a narrower form. The estimates are independent of the shape between elastic moduli. A previously derived formula for the method of multiphase composites was applied to the case of multicomponent matrix media to calculate the strength characteristics. Figures 1; references 10: [illegible] Russian, 7 Western.
[2-6108]

UDC 620.172.251:669.018.9

CHARACTERISTIC FEATURES OF DEFORMATION OF A MODEL LAMINATED COMPOSITE

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 6, Nov-Dec 80 pp 73-77
[Manuscript received 13 Feb 79]

IL'ICHEV, A. I. and POSTNIKOVSKIY, A. A., Khar'kov

[Abstract] Specimens of copper foil annealed at 500°C and electropolished, coated on both sides with thin condensed films of chromium of different thickness in a vacuum, were investigated. The mechanical properties of the composites vary significantly as the thickness of the surface films increases from 0.02 to 1.3 microns. The stress-strain patterns vary significantly as the surface thickness of the films increases during the initial stage of deformation. The slip bands become rougher with an increase in the thickness of the surface films and they disappear completely at a thickness greater than 0.1 micron. The decrease in the plasticity of the composite as thickness increases is possibly caused by intensification of deformation localization. The stresses in layers deformed in the composite can be calculated, the stresses in the foil are independent of the surface thickness of the film and they increase by approximately 20 percent compared to an uncoated foil. Figures 3; references 8: all Russian.
[80-6367]

UDC 624.074:678.067

EXPERIMENTAL AND THEORETICAL INVESTIGATION OF THE LOAD-BEARING CAPACITY OF SLIGHTLY CONICAL COMPOSITE SHELLS IN AXIAL COMPRESSION

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 6, Nov-Dec 80 pp 1047-1055
[Manuscript received 16 Jan 80]

ZHMURKHOTOV, D. S., TIKHONOV, V. A. and KULAGIN, B. V., Central Aerodynamics Institute imeni Professor N. Ye. Zhukovskiy, Moscow

[Abstract] The methods and results of testing in axial compression on slightly conical composite shells made of glass fiber reinforced plastic, carbon fiber reinforced plastic and organoplastic materials are outlined and the experimental results are compared to calculations. Single shells of glass fiber reinforced plastics and organoplastic shells broke down due to loss of stability. Three-ply glass fiber reinforced plastic shells broke down due to loss of stability with formation of a larger bore of a single series of waves extended in the circular direction. Another of these shells broke down with formation of a sloping crack in the outer supporting layer. A circular crack formed in carbon fiber reinforced plastic shells after breakdown in the region of the lower base on the outer supporting layer. The destructive stresses are close to critical for glass fiber reinforced shells, while they are close to the ultimate strength of the wall material for carbon fiber reinforced plastics. Figures 4; references 13: 11 Russian, 2 Western.
[76-6367]

UDC: 620.194

STUDY OF THE INFLUENCE OF THERMOMECHANICAL WORKING ON CORROSION CRACKING OF THE MA2-1 ALLOY

Moscow LABORATORIYA METALLOV in Russian Vol 17, No 1, Jan-Feb 81 pp 70-73 manuscript received 22 Oct 79, after revision 20 Feb 80

TRUFNEVA, L. P., IBAYEV, N. I. and SAFRONOV, D. R., Voronezh Technological Institute

[Abstract] The purpose of this work was to achieve an increase in the resistance of MA2-1 alloy to corrosion cracking by thermomechanical working and to determine the relationship between the incubation period and the period of avalanche fracture. Annealed MA2-1 alloy in the form of a sheet 1.5 mm thick was studied (Al=4.2%, Zn=0.9%, Mn=0.8%). Specimens were subjected to static loading at 0.9% of the yield point in a medium of 30 g/ℓ NaCl plus 60 g/ℓ $K_2Cr_2O_7$. The change in potential as a function of time and elongation were recorded during testing. The time to failure was used as a criterion of corrosion cracking resistance. The incubation period is longest after thermomechanical working consisting of cold plastic deformation by 5%, and heating to 125°C for 10 hours and to 175° C for 10 hours. Fractographic studies show transcrystalline fracture of the alloy in the initial state and after optimal thermomechanical working. After all other types of thermomechanical working, both transcrystalline and intergrain fracture were observed. Figures 1; references 9: 6 Russian, 3 Western.
[26-6508]

UDC: 621.039.193,620.193.01

CORROSION OF STRUCTURAL MATERIALS DURING STARTUP OF A NUCLEAR POWERPLANT

Moscow LABORATORIYA METALLOV in Russian Vol 17, No 1, Jan-Feb 81 pp 104-106 manuscript received 3 Sep 79, after revision 28 Feb 80

SEDOV, V. M., KRUTIKOV, P. G. and NEMIROV, N. V.

[Abstract] An earlier work by the authors demonstrated that the corrosion behavior of structural materials may be influenced by preliminary chemical treatment. The purpose of this work was to determine the stability of this influence. The surface of specimens of type 20 and Kh18N10T steel was treated with solutions consisting of 3 g/ℓ trilon B and 3 g/ℓ citric or lactic acid for 4 hours at 95°C, 8 g/ℓ NH_4NO_3

and NH_4OH to pH 7.0 for 15 minutes at 80° C, 0.5 g/l $N_2H_4 \cdot H_2O$ and NH_4OH to pH 10.5 for 6 hours at 150° C. The thickness of the protective film formed was determined by microscopic examination. Corrosion testing was performed at 100± 5° C at a circulation speed of 2.2±0.2 m/s. The characteristics of the water used in the corrosion test were: [Fe]= 0.05-1.5 mg/kg, [O_2]=0.05-0.8 mg/kg, pH 5.7-6.4, total hardness 700 mg-eq/kg. The total duration of testing was 670 hr. The change in mass of the specimens was determined with an accuracy of 0.1 mg. After 670 hours of testing of type 20 steel, no areas of active dissolution were found. The thickness of the film produced by ammonium nitrate treatment decreased from 10-15 to 4-6 μm, the film produced by hydrazine-ammonia treatment - from 1.5 to 1.0-1.5 μm. Corrosion of the type 20 steel with protective films increased during the last 200 hours. The oxide films were gradually dissolved into the water. The activity of the surface subjected to chemical treatment decreased during the course of the testing. At potentials of -0.4 to -0.2 v, cathodic currents were recorded, indicating partial passivation of the surface. On the whole, the activity remained higher than for type 20 steel not subject to chemical treatment. The changes in Kh18N10T steel were slight and exposure to the aqueous medium caused passivation of the surface, decreasing the current density in the passive area and resulting in disappearance of the area of active dissolution. Thus, after chemical treatment pearlitic steel retains its elevated rate of corrosion in aqueous media for a long period of time. Dense oxide films produced by hydrazine-ammonia treatment retain their protective properties for 670 hours in a moving aqueous medium at 150°C. The surface of austenitic steels is self-passivating. Figures 1; references 5: all Russian.
[26-6508]

UDC: 621.357.7

COMPARATIVE CHARACTERISTICS OF PROCESSES OF ELECTROPRECIPITATION OF INDIUM ALLOYS

Moscow ZASHCHITA METALLOV in Russian Vol 17, No 1, Jan-Feb 81 pp 129-131 manuscript received 27 Jun 77

TOMTOCHEVA, L. S., KRAPIVNAYA, Ye. D., DUNAYEVSKAYA, F. M., KHAINOZHOK, L. N., and LUKODA, L. N., Khar'kov Aviation Institute

[Abstract] The method of mathematical planning was used to study the influence of a combination of various technological factors on the process of electroprecipitation and certain kinetic regularities of the electroprecipitation of indium alloys from amino-tartrate electrolytes. A priori data were used to select the levels and intervals of variation of the independent variables: cathodic current density, the ratio of the quantity of complex formers and the ratio of the quantities of ligands. The influence of current density on the content of indium in the zinc-indium alloy was less than in nickel-indium alloys. An increase in the content of indium in nickel alloy occurs as the molar ratio of concentrations of indium and nickel in the electrolyte is increased, while in a zinc-indium alloy the ratio of concentration of ligands in the electrolyte has a comparable influence. Two mathematical models are presented for the variation of cathode yield per unit current of alloys as functions of the independent variables for the zinc and nickel alloys. At a current density of 0.5-1 A/dm^2, the yield of zinc-indium alloys

remains high over a significant interval of concentration of ligands. The rate of liberation of nickel-indium alloy increases with an increase in current density and with a decrease in the ratio of concentrations of the ligands. Microhardness equations are also produced for the zinc-indium alloys and the nickel-indium alloys as functions of the variables. Analysis of the regression equations indicates that the microhardness of nickel-indium alloys is significantly influenced by the annealing temperature and current density, while the microhardness of zinc-indium alloys is significantly influenced by the concentration of complex formers and ligands in the electrolyte. Long-term testing of the alloys in a moisture chamber produced no corrosion foci, although the alloys became darker. Figures 2; references 2: both Russian.
[26-6206]

UDC: 620.197

CORROSION-RESISTANT ALLOYS AND PROSPECTS FOR THEIR DEVELOPMENT

Moscow ZASHCHITA METALLOV in Russian Vol 17, No 1, Jan-Feb 81 pp 16-33 manuscript received 6 Aug 80

TOMASHOV, N. D., Institute of Physical Chemistry, USSR Academy of Sciences

[Abstract] This article, a report read at the 3rd Conference of Specialists of the CEMA Member Countries on the Problem "Development of Measures for Protection of Metals from Corrosion," Warsaw, April, 1980, outlines principles for creation of alloys with elevated corrosion resistance. A theoretical analysis of the mechanism of corrosion processes indicates that there are 3 possible means for increasing the corrosion resistance of alloys to electrochemical corrosion: 1) decreasing the degree of thermodynamic instability; 2) inhibiting the kinetics of cathodic processes; or 3) inhibiting the kinetics of anodic processes. Several examples are presented clarifying practical possibilities of utilization of these three paths. The possibilities for decreasing thermodynamic instability under the actual conditions in the real world are quite limited. The primary trend which can be used today is to create alloys which undergo a spontaneous transition to the passive state over the broadest possible range of corrosion conditions. This is usually achieved by directly inhibiting anodic processes by the addition of a passivating component, as in stainless steels. Another method is by increasing the effectiveness of the cathodic process by the addition of small quantities of corrosion-resistant metals with low hydrogen overvoltage, to shift the electrode potential in the positive direction. This can sometimes be achieved with fractional percentage alloying. Proper application of cathodic modification, it is shown, can increase the corrosion resistance of alloys by several orders of magnitude. A number of modern structural metals are described and the prospects for the development of corrosion resistant alloys outlined. Metals discussed include stainless steels, new high-chromium ferritic stainless steels, cathodically modified stainless steels, corrosion-resistant titanium alloys, chromium-based alloys and amorphous alloys. Amorphous alloys are primarily produced by rapid cooling from the liquid state (10^5-10^7° C/s). Although it is noted that most works on amorphous alloys are as yet sensational in nature, their singular properties will doubtless win certain areas of application for them, probably initially in instrument building

and in electronics. If experiments are successful in creating an amorphous layer on compact alloys by laser melting or application of a thin amorphous layer onto finished metal parts, the use of amorphous alloys may increase greatly. Prospects for the near future include further study of the phenomenon of passivity and factors increasing the resistance of passive layers, studies of local types of corrosion such as pitting, intercrystalline corrosion and corrosion cracking, mastery of methods of production of high purity chrome steels, production of alloys based on plastic chrome with catalytically modified additives, further study and improvement of catalytically modified titanium alloys and stainless steels, development of optimal methods for surface alloying, and the study and development of metal-ceramic and composite alloys with high strength and corrosion resistance. Figures 11; references 47: 23 Russian, 24 Western.
[26-6508]

UDC: 622.341.1.002.2:338.45"313"

FERROUS METALLURGY MINING INDUSTRY ON THE THRESHOLD OF THE 26th CPSU CONGRESS

Moscow GORNYY ZHURNAL in Russian No 1, Jan 81 pp 3-7

[Article by V. S. Vinogradov, USSR deputy minister of ferrous metallurgy]

[Text] The USSR's ferrous metallurgical workers, just as the entire Soviet people, are totaling up the results of this past five-year plan and are specifying new targets in the area of further growth and development of the mining industry in order to provide the metallurgical workers of the Soviet Union and the brother socialist nations with high-quality raw materials.

In the 10th Five-Year Plan,* capital investment in production facilities in the iron mining industry totaled 3.9 billion rubles, or 24 percent more than in 1971-1975. Outlays on replacing obsolete mine transport equipment and adoption of new equipment increased substantially. A total of 307 million rubles were spent under this item heading. Each year there was an increase in expenditures on expansion and renovation of existing mining enterprises (from 270.3 million in 1975 to 363.1 million rubles in 1979). Almost 28 percent of all capital expenditures were on construction of new mining enterprises.

Production capacity added during the first four years of the 10th Five-Year Plan for the ministry as a whole was as follows: 103.7 million tons for raw ore mining, and 33.4 million tons of merchantable ore. Large raw and merchantable ore capacities were added during these years at the following mining and beneficiation combines: Lebedinskiy -- 21.2 and 7.1 million tons respectively; Severnyy -- 18.0 and 6.9 million tons respectively; Dneprovskiy -- 15.0 and 5.3 million tons. Construction continued on the Kostomukshskiy and Kacharskiy mining and beneficiation combines.

Iron ore industry enterprises occupy a leading position among mining enterprises within the USSR Ministry of Ferrous Metallurgy system. For example, in 1979 the commodity output volume of the mining industry was 3,417.2 million rubles, of which the iron mining industry accounted for 87.2 percent, manganese -- 7.5 percent, chromite -- 1.6 percent, and non-ore mining -- 3.7 percent of total commodity output volume.

Iron ore production volume grew more rapidly at open-pit operations than for the iron mining industry as a whole. In 1975 363.2 million tons of iron ore was

* Preliminary figures are given for 1980 and for the 10th Five-Year Plan as a whole.

surface-mined, while the figure for 1979 was 404.7 million tons, or 11.6 percent greater, while production growth was 9.1 percent for the iron mining industry as a whole.

Manganese ore production volume increased by almost 15 percent, totaling in excess of 23 million tons in 1980, with an average manganese content of 23.4 percent in the ore. Chromite ore production volume reached 3.4 million tons.

In 1980 84.6 percent of the ministry's total iron ore production was surface mined (82.2 percent in 1975). Concentration of production took place primarily by expansion and renovation of enterprises. In 1979 219.3 million tons of raw ore were produced at eight large open-pit mines with an annual production capacity in excess of 20.1 million tons, or 54 percent of the total volume of surface-mined ore. At the present time 19 large underground mines, ranging from 2.0 million to 4.5 million tons annual production capacity, are providing approximately 80 percent of underground-mined iron ore production.

Volume of waste rock in open-pit mines has increased, totaling 290.6 million cubic meters in 1979. Intensification of surface mining has led to a significant increase in the depth of operating open-pit mines. Depth increased by 15-20 meters in the period 1976-1980, with an average annual deepening rate of from 5 to 12 meters. In 1975 the maximum depth of the deepest open-pit iron mines -- the Sokolovskiy and Sarbayskiy -- was 280 meters, while in 1980 it exceeded 300 meters.

Iron content in underground-mined raw ore declined as a result of extensive initiation of mining low-grade ferruginous quartzite and titanomagnetite ore bodies. In 1980 this figure was 35 percent, as compared with 36.2 percent in 1975; the figures for pit-mined ore are 33.1 and 34.2 percent respectively, while retaining the quality of concentrate and merchantable ore. This situation is leading to an increase in the percentage share of expenditures on ore preparation.

Open-pit mining operations. One feature of development of open-pit iron mining in the USSR is an increase in the depth of open-pit mines and their productivity, both in ore and waste rock. In 1979 53 percent of total iron ore and waste rock was produced at open-pit mines 200 meters deep or more, with an average mine rock production figure of 35 million tons per year. Average productivity of deep open-pit mines will increase substantially by 1990.

Mining operations experience, scientific research and projected figures indicate that there will occur in the 11th-12th Five-Year plans a decline in production capacity at open-pit iron mines, due to increase in depth and size of mines, worsening of mining conditions, and diminished productivity of mine transport equipment.

Therefore one of the principal tasks in planning future development of mining operations is maintaining the existing production capacity of mining enterprises by digging down to and working deep levels and by bringing into production adjacent new sections of ore bodies. The main problem of open-pit mine development is the problem of in-mine transport. According to available figures, the percentage share of expenditures on transporting waste rock and ore amounts to 40-50 percent of total mining costs. As mining operations go deeper, productivity declines on mine trucks, excavators and other mining equipment.

In order to diminish the influence of this factor and increase the efficiency of open-pit mining operations, the ministry is taking steps to intensify the conduct of mining operations by improving ore body exploitation and exposure procedures.

Draft and principal technical decisions which guarantee efficient working of ore bodies in the future, based on extensive employment of cyclic-continuous processes and large unit capacity mine transport equipment, have now been approved for all open-pit mines under construction, under renovation and in operation.

A full-scale TsPT [Cyclic-Continuous Process] system has been in operation at the Ingulets Mining and Beneficiation Combine since 1974, with an anual raw ore handling capacity of 20 million tons. Employment of a TsPT has made it possible to increase open-pit mine productivity by 80 percent and to reduce by 10 percent the cost of mining a ton of ore. The experience of the Ingulets Mining and Beneficiation Combine indicated that the cost of transporting ore by conveyer was reduced from 7.96 to 4.78 kopecks per ton.

Similar positive experience has been gained at the Annovskiy open-pit mine of the Severnyy Mining and Beneficiation Combine, where the first unit of a TsPT, with a capacity of 20 million tons per year, was brought on-line on the basis of a plan prepared by the Yuzhgiproruda Institute. The ore is crushed by a KKD-1500/180 crusher, and transported by a conveyer with a belt 2000 mm in width. In 1979 10 million tons of ore was produced with utilization of this system. Employment of a TsPT at the Annovskiy open-pit mine made it possible to shorten haulage distance by 1.8 km and to reduce the cost of transport by 51 percent. In 1979 a second main conveyer belt was constructed at this same mining and beneficiation combine, with a capacity of 20 million tons per year, for moving overburden.

In 1979 a TsPT system with an annual capacity of 20 million tons of ore was built at the Yuzhnyy Mining and Beneficiation Combine. Wide-gauge rail transport was employed as gathering component. In 1980 this system moved 10 million tons of ore out of the open-pit mine. Plans to convert 12 open-pit iron mines, including all Krivoy Rog surface mines, to TsPT have been approved up to the present time.

Practical experience indicates that improvement in the efficiency of mining operations is promoted by extensive employment of electrified rail transport, at great depths in particular. The percentage share of haulage by electrified transport reached 23 percent in 1979. The principal directions being taken in improving electrified rail transport is extensive utilization of powerful PE2M OPE1A and OPE2 locomotive units, with an adhesive weight of 360 tons, which makes it possible to increase track gradients to 6 percent. Optimization of the dimensions of external trenches in removing overburden, their quality and location, taking into account employment of rail transport at deep levels, makes it possible to reduce the volume of moved earth and rock, the height to which motor transport must haul ore and rock, and haulage volume.

In order to increase the limits of employment of rail transport at large open-pit mines, inclined adits can be used (under construction at the Sarbayskiy open-pit mine and under consideration at other deep-pit mines).

In spite of an increase in merchantable iron ore production volume from 232 million tons in 1975 to 247 million tons in 1980, the volume of ore and rock removed in

1980 remained at the 1975 level due to a decrease in volume of overburden removal. Alongside objective reasons for the lag in overburden removal activities, such as inadequate availability of means of transport, non-delivery of mining equipment specified by the plan, plus others, we should point to poor organization of planning and execution of mining operations, and low productivity of mine transport equipment due to its poor utilization in principal operations at a number of enterprises.

At open-pit mine drilling operations, the 5SSh-2M, 2SSSh-200, and SSSh-250 drilling machines were replaced with SSSh-250MN units. In 1979 more than 80 percent of total volume of ore and rock blasted at the open-pit mines of this branch were drilled with SSSh-250MN units, while annual output per officially on-line unit increased from 18,000 meters in 1975 to 21,000 meters. At the open-pit mines of the Mikhaylovskiy, Lebedinskiy, Dneprovskiy, and Novokrivorozhskiy Mining and Beneficiation combines, however, average annual drilling output is below the branch average, and comprises 13.8, 18.6, 18.5, and 17.9 thousand meters respectively. The low output of SSSh-250MN units at these enterprises is due not only to worsening of ore body mining conditions but also to considerable unit downtime as a consequence of deficiencies in servicing and maintenance, delayed and poor-quality maintenance, unwarrantedly large runs, etc.

Durability of rolling cutter bits remains poor. According to studies made by branch institutes, the durability of the rolling cutter bits presently being used can be increased by 20-25 percent by establishing at all enterprises stations for readying drill bits for operation.

The increasing depth of mining operations, an increase in the volume of hard-to-blast rock and ore, and the low level of mechanization of auxiliary operations are resulting in an increase in labor expenditures on blasting preparations. At the present time labor outlays per ton of explosives amount to 2.6 man-shifts.

The main factor hindering the adoption of total mechanization of blasting operations is the lack of equipment for mechanizing a number of loading-unloading, warehouse and other operations and processes. The Ministry of Heavy and Transport Machine Building has not yet developed any equipment other than charging and tamping machines. And even these are being produced in small quantity and fail to meet the requirements of mining enterprises.

In recent years the open-pit mines of this branch have taken delivery on EKG-8I, EKG-4.6, and EKG-6.3US excavators.

At the present time the percentage share of EKG-8I, EKG-8 and EKG-4.6 excavators is 72.8 percent, and excavators with an 8 cubic meter bucket -- 32.4 percent. Upgrading of the excavator fleet is proceeding slowly, however.

In order to achieve a significant improvement in excavator fleet performance figures, it is necessary to speed up replacement of obsolete, worn-out units, to improve the quality of excavator maintenance, and to support excavation and loading operations with adequate-capacity means of transport and mobile equipment for performing auxiliary jobs.

Reduction in the number of persons employed on auxiliary processes constitutes a principal reserve potential for boosting labor productivity in transport. Track laying and maintenance is such an auxiliary process in open-pit mine rail transport.

At the present time mining enterprises are operating approximately 2,000 kilometers of in-mine tracks, more than half of which falls within the category of movable tracks. During the period 1976-1980 average labor requirements for operating 1 kilometer of movable tracks at open-pit mines of the USSR Ministry of Ferrous Metallurgy declined from 720 to 600 man-shifts per year, while labor productivity in moving and relaying tracks rose by 15-18 percent, with a substantial improvement in the level of mechanization of track laying and maintenance. Further improvement of these figures is essential, however.

A substantial reduction in labor requirements in operating movable tracks (by 50-67 percent) can be achieved by shifting over to centralized track maintenance at mine unit maintenance bases.

Truck hauling operations at open-pit iron mines have been boosted by the addition of 40-ton BelAZ-548A dump trucks, and since 1978 -- BelAZ-549 (75-ton), which comprised 64.2 percent of the total number of heavy-load trucks on line. The average load capacity per official-roster truck reached 36.3 tons as compared with 30.5 tons in 1975. Rock and ore haulage volume increased to 640 million tons, with the bulk hauled from deep levels in the mines. With heavy-load dump trucks, motor transport average branch productivity is inadequate, at 6,660 tons per year per ton of load capacity. At such enterprises as the Sokolovsko-Sarbayskiy, Ingulets and Severnyy Mining and Beneficiation Combines, output per ton of load capacity ranges from 7,200 to 8,600 tons per year.

Motor transport support facilities have improved during this last five-year plan. The total value of buildings and other structures for truck servicing and maintenance has increased by 22.8 percent for the ministry as a whole. Motor transport shop production buildings have come on-line at the Lebedinskiy, Kovdorskiy, Stoylenskiy, and Sokolovsko-Sarbayskiy Mining and Beneficiation combines. Fully mechanized production lines for servicing and maintenance of BelAZ-540A and BelAZ-548A dump trucks have been set up and are successfully in operation at the Ingulets, Severnyy, Dneprovskiy, and Novokrivorozhskiy combines. Mechanized stations for mounting and taking off large wheels and tires have been set up, and enclosed truck washing units have been built at the majority of enterprises. More than 100 different nonstandardized means of mechanization and test benches have been developed and built by enterprise resources and manpower.

The percentage share of manual labor in preparation work in transport remains high at 46 percent. The situation is particularly difficult in the area of mechanization of servicing and maintenance operations for the 75-ton BelAZ-549 dump trucks. The USSR Ministry of Automotive Industry, other agencies and manufacturers are not devoting adequate attention to solution of this critical problem. And yet employment only of such mobile mine equipment as a refueling truck, mobile maintenance shop and diagnostic station will make it possible to reduce fuel consumption per BelAz-549 dump truck by 20 tons per year, reduce spare parts requirements, and reduce tire wear by 10 percent.

Upgrading of the truck fleet by acquiring large load-capacity BelAZ-7548 (45 tons), BelAZ-549 (75 tons), and BelAZ-7519 (110 tons) dump trucks, establishment and renovation of production facilities, and improvement in the level of truck servicing and maintenance are most important tasks in the area of intensification of motor transport operations in the near future.

Underground mining operations. At the present time underground mining is being done at 40 mines (22 in the Ukraine, 9 in the Urals, and 6 in Siberia); these operations are characterized in the principal iron mining areas by increasing depth, shrinking ore bodies, and the effect of rock pressure. Expanding the raw materials base of underground mines has its own specific features: a decisive role in the Krivoy Rog basin is being assumed by mastery of the technology of mining and processing magnetite-quartzites, occurring to a depth of 1,000 meters in the working areas of existing mines, for the Urals -- the deep-lying ore bodies of the Nizhniy Tagil-Kushva area and the Kurgan Trans-Urals, and for Siberia -- mining of iron ore at deep levels of ore bodies presently in exploitation.

Underground mines are presently employing modern techniques of exposing and preparing ore bodies, with increased-height levels, concentration levels and crusher-bunkering complexes. High-productivity versions of level and sublevel induced caving systems have been widely adopted, as have optimal borehole ore breaking parameters, vibration removal of broken ore from blocks, etc. Substantial success has been achieved in concentration of mining production.

In the 10th Five-Year Plan eight large mines in this branch achieved worker labor productivity or 20-24 tons per shift. Average labor productivity for all operating mines of this branch is 13-16 tons per shift, and was as follows in 1979 for the principal regions: Krivoy Rog basin -- 12.6; Urals -- 14.7; Western Siberia -- 19.6 tons per shift. At the same time, the rate of labor productivity growth declined in the 10th Five-Year Plan at many mines. At 19 large mines average annual labor productivity growth for 1975-1979 was only 2 percent, and only 1.1 percent in the Krivoy Rog basin. A decline in the rate of labor productivity growth in the 10th Five-Year Plan is characteristic of all principal regions, including Western Siberia.

Stabilization of labor indices at underground iron mines is partially due to worsening of the mining conditions of the exploited ore bodies, but the main reasons are exhaustion of the reserve potential of the mining equipment being employed, plus poor mechanization of auxiliary jobs. It is essential to design and produce in quantity new equipment for preparation, stoping and auxiliary operations and, on this foundation, to come up with improved underground ore mining schemes, including production-line mining. This will significantly increase labor productivity.

Problems pertaining to development of the raw materials base of underground ferrous metal ore mining and mine equipment upgrading were discussed at a national conference on development and improvement of the technical level of ore mining, held in October 1980 in Nizhniy Tagil, organized by the USSR Ministry of Ferrous Metallurgy and the Central Board of the Scientific and Technical Society for Ferrous Metallurgy. The recommendations adopted at this conference confirm the critical importance of this problem and include a list of concrete measures which ensure development and improvement of underground ferrous metal ore mining in the 11th Five-Year Plan and beyond.

Preparation of ores. Considerable success was achieved during the 10th Five-Year Plan by the work forces of concentration, agglomeration and pelletizing mills. In 1980 approximately 415 million tons or more than 84 percent of all raw iron ore went through dressing operations. Iron content in merchantable ore and concentrate was 59.5 and 62.4 percent respectively. New production facilities at the concentration

mills of the Lebedinskiy, Severnyy, Novokrivorozhskiy and Dneprovskiy Mining and Beneficiation combines came on-stream.

The technical level of beneficiation improved. New high-output equipment was installed at concentrating mills: KKD-1500/250-160 crushers, 82 cubic meter ball mills, 160 cubic meter self-grinding mills, PBM-90/250 magnetic separators, etc. We should note that equipping concentrating mills with new, high-output equipment is still taking place excessively slowly, while the reliability of the equipment being manufactured remains poor.

In connection with worsening of ore grade and increase in the volume of processed ore, measures are needed which ensure a substantial increase in iron content. Such measures include grinding to a smaller size, incorporation of final concentration operations (fine screening, selective desliming), and others.

New production capacity has been put on-line at pelletizing mills during these years. Two OK-520 roasting units were put into operation at the Mikhaylovskiy Combine, a second pelletizing mill with two OK-306 roasting units at the Lebedinskiy Combine, two units with a roasting area of 552 square meters at the Severnyy Combine, and two grate-tube furnace lines at the Dneprovskiy Combine.

An important advance in the area of preparation of manganese ores during this period was introduction at the Chiaturmarganets Combine of concentration of carbonate ores in turbulence-type hydraulic cyclones with heavy suspension. Adoption of flotation concentration of manganese sludges boosted manganese recovery, in spite of a decline in manganese presence in the raw ore.

In the future, the main trends in the area of preparation of manganese ores will be changing over mills to the production of concentrates of lump and agglomeration size, increasing manganese recovery in the concentrate, production of concentrate meeting the requirements of ferroalloy production, improvement in utilization of carbonate ores, and development of an aggregate of new, efficient equipment for concentrating mixed and carbonate manganese ores.

In the iron mining industry, labor productivity in gross output increased by 4.9 percent in the first four years of the 10th Five-Year Plan, with a 5.1 percent increase for raw iron ore. Labor productivity for merchantable ore remained practically unchanged in connection with a 1.3 percent decline in iron content in the raw ore and an increase in raw ore consumption per ton of merchantable ore. For the iron mining industry as a whole, output volume growth in 1979 over 1975 due to labor productivity growth was 140.9 million rubles for gross production and 23.3 million tons for raw ore.

High labor productivity in merchantable ore output per worker was achieved at the Yuzhnyy (2,778 tons), Ingulets (2,663 tons) and Novokrivorozhskiy (2,235 tons) combines.

The highest labor productivity levels achieved at iron mining enterprises in the 10th Five-Year Plan exceed the corresponding figures in the Ninth Five-Year Plan by 16 percent in value terms and 8 percent in physical terms. The highest mine worker per-shift labor productivity was achieved at the KMAruda Combine (23.8 tons), at the Abakanskiy (22.6 tons), Sheregeshskiy (22.5 tons) and Tashtagol'skiy (22.0 tons) mines.

Competition between brigades to achieve the highest equipment productivity was conducted on a large scale at iron mining enterprises during the years of the 10th Five-Year Plan. In 1979 95.8 percent of brigades of principal job occupations at open-pit mines were involved in this type of competition for the USSR Ministry of Ferrous Metallurgy as a whole. Socialist competition made it possible to increase average annual output of an EKG-8I excavator for the USSR Ministry of Ferrous Metallurgy as a whole from 1,102,000 m^3 of ore and rock in 1974 to 1,251,500 m^3 in 1979; drilling machines -- from 20,200 meters of borehole in 1976 to 21,700 meters in 1979; locomotives during this same period -- from 1,112,000 tons of ore and rock to 1,282,000 tons.

The highest mining equipment productivity was achieved by the drilling brigades of V. V. Kulak (YuGOK), N. I. Shelkovnikov (SSGOK), Ye. I. Startsev (Korshunovskiy GOK [Mining and Beneficiation Combine]), V. G. Danilyuk (SevGOK); the excavator brigades of V. K. Mironenko (YuGOK), V. M. Yermolovich (SSGOK), P. Ye. Gil' (TsGOK), and Yu. A. Shel'gorn (Donskoy GOK); the locomotive brigades of A. V. Karskanov (Lebedinskiy GOK), V. R. Sychev (Kachkanarskiy GOK), and N. P. Zubriy (YuGOK); the motor transport brigades of A. Kh. Bostandzhan (Olenegorskiy GOK), M. A. Zinaliyev (SSGOK), and N. P. Rybak (TsGOK).

At many enterprises there occurred further development of socialist competition between work forces of enterprises of related branches of industry. In 1980 competition under the slogan "Ore-Metal-Machine" was conducted by the work forces of the KMAruda Combine, the Novolipetsk Metallurgical Plant, and the Voronezh Mining and Beneficiation Equipment Plant. The miners of the Sokolovsko-Sarbayskiy GOK are in competition with the work force of the blast furnace shop at the Magnitogorsk Metallurgical Combine. In connection with the forthcoming 26th CPSU Congress, new patriotic initiatives were born and given broad support in work forces.

Ferrous metals mining science experienced further development in 1976-1980. Each year approximately 12 million rubles are spent on scientific research and development projects conducted by seven mining-specialization branch institutes. The total number of scientific personnel employed by these institutes increased by almost 17 percent during the five-year period. The number of higher-qualification scientific personnel -- doctors and candidates of sciences -- increased.

On the basis of research conducted by scientific research engineering institutes, design institutes prepared 19 plans for converting open-pit mines over to new technology, and 17 of these were approved for implementation. The volume of ore and rock removed with utilization of new technology totaled 135 million tons for the 10th Five-Year Plan, reaching a figure of 45 million tons in 1980.

The most important tasks of the mining enterprises of the USSR Ministry of Ferrous Metallurgy and scientific research organizations included problems pertaining to industrial health and safety, improving safety procedures and miner working conditions. Work was conducted in this area both on developing equipment and devices for safe work methods at work stations and securing safe and comfortable working conditions in shops and at enterprises as a whole.

Particular attention was devoted in the 10th Five-Year Plan to scientific research aimed at resolving an important problem for the national economy -- efficient utilization of natural resources and protection of the environment. Suffice it to say

that the volume of work performed on this problem in the mining industry of the USSR Ministry of Ferrous Metallurgy has doubled in the last three years, while the volume of implementation of scientific research results has increased almost five-fold.

At all enterprises there has been an improvement in internal combine planning on the basis of improving engineer substantiation of targets assigned to each shop, section, and unit; establishment of targets pertaining to level of utilization of equipment and degree of route overfulfillment. Provisions on cost effectiveness analysis have been revised and adopted, provisions collecting matters pertaining to enforcing internship pledges and the specific features of brigade economic accountability.

Scientific research and design institute personnel, industrial enterprise engineers and technicians must do the following in order to achieve an improved technical level of the mining industry of the USSR Ministry of Ferrous Metallurgy and increased efficiency of mining production during the years of the 11th Five-Year Plan:

expand adoption of [illegible] processes at the enterprises of the Krivoy Rog basin, the Kursk Magnetic Anomaly, and in the Northwest; bring experimental-industrial systems on-line at the Yeshkanovskiy and Central Mining and Beneficiation Combines;

conduct research and take practical measures to achieve intensification of overburden removal, including substantial improvement in the utilization of rotary equipment;

take measures to expand the area of employment of rail transport in open-pit mines;

establish specialized enterprises to perform blasting operations (of the "Vzrybvneruprom" type) in all this country's major mining regions, which will make it possible to improve organization of blasting operations, increase equipment utilization safety and boost equipment productivity;

shift over to track laying and maintenance operations with centralized track maintenance, and boost the level of mechanization of track laying and maintenance operations to 80-85 percent, which will make it possible to increase overall labor productivity at open-pit mines by 12-15 percent;

focus particular attention on development of mines and areas of mechanization of the most labor-intensive auxiliary and maintenance activities in open-pit and underground mines;

accomplish ahigh elaborate measures for efficient and comprehensive utilization of mineral resources, to improve the quality and degree of blasting of ores, adoption of no-waste mining production technology, as well as in the area of environmental protection and reclamation of disturbed land;

expand research on and adoption of self-propelled equipment, vibration equipment, and production-line technology in underground mines;

develop efficient and safe methods of underground-mining ore bodies at depths of 1,200-1,500 meters;

on the basis of research, draft proposals aimed at improving organization of labor, production management, and adoption of progressive labor methods and advanced know-how.

As we approach the forthcoming 26th CPSU Congress, ferrous metallurgy miners are honorably accomplishing their assigned tasks.

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POWDER METALLURGY ADVANCES IN AZERBAIJAN

Baku BAKINSKIY RABOCHIY in Russian 14 Jan 81 p 2

[Article by Candidate of Technical Sciences F. Mamedov, Chairman, Committee on Powder Metallurgy of the Azerbaijan Scientific and Technical Society: "Prospects of Powder Metallurgy: Scientific and Technical Progress"]

[Text] In recent years BAKINSKIY RABOCHIY has regularly published materials on the conditions and possibilities for establishing a new branch of industry in this republic -- powder metallurgy. We shall recall that these articles examined the areas of application of powder metallurgy materials and products, concrete examples and possibilities of utilization of sintered and spray-coated items, as well as powders proper in various machinery and equipment. On the basis of results of a survey of this republic's metallurgical, machine building and metalworking enterprises, the articles showed Azerbaijan's growing need for powder metallurgy materials and products in the period 1981-1990, and also revealed a raw materials base for producing various metal powders of mineral ores, concentrates and production waste materials, by means of comprehensive processing, reduction, separation and pulverization of Dashkesan magnetite, Zaglikskiy alunite, Paragachay molybdenite, Filizchay polymetals, Sumgait rolling mill scale, and chips of certain traditionally employed alloy steels produced in large quantities at plants in this republic.

These materials discussed the economic effectiveness of employment of materials and products as well as powder coatings in Azerbaijan's economy. They noted the advisability of designing and building equipment, furnace equipment in particular, for the needs of powder metallurgy at the Azerelektroterm Association. Much has changed in this most recent five-year plan, and I should like to relate what has been accomplished and what still remains to be done, examining various aspects of this problem in light of the draft of the Principal Directives of This Country's Development.

I should like to begin with the following point contained in the draft: "Enhance the role of scientific and technical societies in acceleration of scientific and technological advance." By decision of the presidium of the Azerbaijan Council of Scientific and Technical Societies, a public intersectorial Committee on Power Metallurgy was established, which engages in extensive publicity of powder metallurgy in this republic, enlisting the aid of national and republic academic, branch and training institutes and industrial enterprises, organizes national and republic conferences, seminars and schools, drafts recommendations and participates in adoption of powder metallurgy methods in this republic's economy, and publishes

summaries and materials pertaining to these scientific and technical measures. This year the Committee on Powder Metallurgy will be holding, jointly with the appropriate national and republic organizations, the 4th All-Union Seminar on Properties, Preparation and Application of Sprayed Metal Powders.

The draft states: "Develop and adopt highly efficient methods of increasing the strength and corrosion resistance of metals and alloys, increase production of new structural materials, coatings and products based on metal powders, alloy powders and refractory compounds." At the present time a number of Azerbaijan scientific research and design institutes, with the participation of academic and branch institutes in Moscow, the Ukraine and Belorussia, are developing, testing and adopting at Baku plants and in offshore oil and gas fields test specimens of wear resistant and erosion resistant machinery and equipment parts and components, metal structures and tools based on metal powders, powders of hard alloys, and sprayed-on powder coatings.

Recently the departments of physical-technical, mathematical and chemical sciences of the Azerbaijan SSR Academy of Sciences, together with branch, academy and educational institutes and industrial enterprises in this republic, discussed, drafted and coordinated with all executing entities comprehensive programs on the most important scientific research problems pertaining to development of powder metallurgy in this republic in the 11th Five-Year Plan and in the period up to 1990. These programs call for determining and changing in the immediate future the thrust of research and development, the organizational structure of this republic's scientific establishments, and strengthening of their testing and manufacturing facilities.

For ferrous metallurgy, the CPSU Central Committee Draft Program calls for... more than tripling production of metal powder.... More extensively employing metal-containing waste materials in production. Build small-capacity metallurgical plants at places of formation of scrap iron and steel and consumption of metal products."

The products of this republic's ferrous metallurgical enterprises (iron concentrate, rolling mill scale and, in the future, pickling sludge from manufacture of pipe with anticorrosion coatings, iron and steel scrap and chips) is an indispensable raw material for production of iron and steel powders. In this connection I feel that it is advisable to include the following among the most important targets for the Azerbaijan SSR: build a plant to produce steel and iron powders. The USSR Ministry of Ferrous Metallurgy should determine the matter of designing and building such a plant, with an annual production capacity of 150-200 thousand tons of metal powder, for meeting the needs of this republic. At the present time tens of thousands of tons of rolling mill scale from primary settling tanks at the Azerbaijan Pipe Plant imeni V. I. Lenin, with an iron content up to 70 percent, are hauled each year to the Rustavi Metallurgical Plant, while scale from secondary settling tanks, with an iron content up to 60 percent, is relegated to the dump. Tens of thousands of tons of steel and iron chips from this republic's metallurgical, machine building and metalworking plants, including several thousand tons of high-alloy steel chips, are rusting away in open dumps, and subsequently burned up, resulting in loss of valuable components, in open hearth and other furnaces at Azerbaijan, Taganrog and Novolipetsk metallurgical enterprises. Meanwhile plant and institute engineers and technicians are continuing a persistent search for more "efficient" methods and techniques of converting metal into chips by replacing one metal cutting machine tool with another.

The draft plan calls for improving in nonferrous metallurgy the technology of mining and processing ores and concentrates and achieving more comprehensive utilization of mineral raw materials. Production of aluminum and copper powders, and precision unreground hard alloy and cermet plates is to grow at a priority rate. There is to be a substantial increase in processing of nonferrous metal waste materials.

Nonferrous metallurgy is developing at an accelerated pace today in Azerbaijan. In order to meet the nation's needs, the list of major construction projects of the 11th Five-Year Plan includes construction of the country's first shop for the production of copper and copper alloy powders by the spray method. The first commercial metal spraying unit was put on-stream ahead of schedule at this facility. At the present time, in order to ease the nation's shortage of hard-alloy tools and abrasive powders, experimental batches of hard and refractory compounds are being produced in small quantity.

But this is totally inadequate. Annual requirements in hard-alloy wear resistant products and tools in our republic alone are being met by only one third. The Nonferrous Metals Administration could eliminate this shortage by enlarging existing facilities, building new facilities to produce powders of hard and refractory compounds as well as powders of vanadium, titanium and aluminum oxide (by processing alumina production waste), molybdenum (by processing molybdenum intermediate product), and manufacturing products and tools based on these powders. In order to speed up execution of these tasks and resolving of organizational problems, it would be expedient to establish in the Nonferrous Metallurgy Administration an Azerbaijan affiliate of the Moscow Orgprimtverdosplav special design and engineering office.

The draft Principal Directions focus special attention on expansion and establishment in machine building and metalworking of new specialized enterprises and large shops manufacturing components of branch and interbranch designation, as well as the necessity of substantially reducing metal production waste and losses by replacing manufacturing processes based on cutting metal with economical parts shaping methods.

We can already note with satisfaction that the USSR Ministry of Chemical and Petroleum Machine Building, in conformity with determined need and plans developed by the All-Union Scientific Research, Planning and Technological Institute of Petroleum Machine Building, at the request of Azerbaijan SSR Gosplan and the Soyuzneftemash All-Union Production Association, has added to the list of the ministry's major construction projects for the 11th Five-Year Plan a large-capacity interbranch powder metallurgy shop with an output capacity of 10,000 tons of sintered and sprayed machinery and equipment parts, which are today manufactured by machining (cutting) methods. In addition to this ministry's plants, which are located all over the country, this shop, which is to be located on the grounds of the Plant imeni Dzerzhinskiy, will also supply enterprises of the petroleum, gas, electrical equipment and other industries, both within this republic and elsewhere.

Initial data for the engineering part of the project have been prepared and submitted to the main design institute. Establishment of such a shop will produce savings of up to 5 million rubles, will free more than 200 metal-cutting machine tools and 500 machine tool operators, and will save approximately 6,000 tons of rolled ferrous and nonferrous metals.

...Now let us look ahead at our republic at the point of juncture between the 11th and 12th Five Year plans. Successful operation of two or three highly mechanized and automated powder metallurgy shops or plants built in our republic provides thousands of tons of annual production of powders, sintered and sprayed products. Production outlays were recouped in the first two or three years after production started up, and in addition the operation of these enterprises does not have any adverse effects on the environment, with minimal consumption of water resources. On the contrary, the water vapor and carbon dioxide generated in sintering operations have a beneficial effect on the ambient biosphere, and in addition there is no solid or liquid production waste -- rejects are returned to the production cycle -- powder metallurgy is an ecologically clean process. And this is a direct response to the point in the CPSU Central Committee Draft Document on Environmental Protection which states: "Improve industrial processes with the aim of reducing discharge of harmful substances into the atmosphere and improving removal of harmful impurities from waste gases."
[27-3024]

3024
CSO: 1842

THE WEAR RESISTANCE OF THE PROTECTIVE LAYER OF SECONDARY STRUCTURES DURING SMOOTH WEAR OF STEELS IN A VACUUM

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian No 6, Nov-Dec 80 pp 92-96 manuscript received 26 Jun 79

LEBEDEVA, I. L., LYUBARSKIY, I. M. and VVEDENSKIY, Yu. V., Physicotechnical Institute of Low Temperatures, Ukrainian SSR Academy of Sciences, Khar'kov

[Abstract] The phase state of the protective layer of secondary structures formed on the frictional surface of chrome-nickel stainless steels with different austenitic stability and the dynamics of breakdown under high vacuum conditions were investigated. Austenitic class 12Kh18N9 tin steel and martensite-ferrite class 14Kh17N2 steel were used as the specimens. There are two critical rates of wear for the given specimens and the type of wear changes when these levels are reached. The intensity of wear increases gradually with length for 12Kh18N9T steel in the rough wear mode when the specimens are exposed to friction. The intensity of wear for both 12Kh18N9T and 14Kh17N2 steels decreases and remains fairly constant in the smooth wear mode. The microhardness distribution curves on the working surface of an indenter made of 14Kh17N2 steel vary significantly at different sliding rates. When the wear resistance of steels is increased during friction in a vacuum by formation of friction martensite, surface breakdown is localized in the harder secondary structures and wear intensity is reduced sharply. Figures 4; references 8: 7 Russian, 1 Western.
[30-6521]

UDC: 539.4.019.3:669.018.25

INFLUENCE OF ELECTRIC FIELD ON MICROHARDNESS OF STEEL UNDER THE INFLUENCE OF LASER RADIATION

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 5, Sep-Oct 80 pp 3-6 manuscript received 25 Jun 79

UGLOV, A. A. and GALIYEV, A. L., Moscow

[Abstract] A study is made of the effect of laser radiation on materials to which an electric field is applied, leading to additional acceleration or deceleration of the ions of the gas surrounding the target. The study is performed by

applying pulses of neodymium laser radiation to a disk of type 1Kh18N9T stainless steel in an atmosphere of nitrogen at pressures of 10 to 110 atm with an external electric field. The radiation flux density was $3 \cdot 10^4$-$5 \cdot 10^6$ W/cm^2. The electric field voltage was 0 ± 400 V, with the energy of the external electric field not over 10% of the maximum laser radiation energy. The voltage source was a condensor. The curve of microhardness of the target surface as a function of pressure has a peak at around 80 atm as long as the radiation flux density is above the threshold value of $2 \cdot 10^5$ W/cm^2. The microhardness varies as a function of the magnitude and polarity of the electric field voltage. The plasma near the solid target changes the microhardness of the surface of the specimen, since when no plasma is present no change is observed in the microhardness of the surface, although the thickness of the melted layer of metal is no less than when a plasma is formed. A second maximum on the curve of microhardness as a function of pressure indirectly indicates that when no external field is present at pressures below 40 atm the degree of ionization of the gas surrounding the target is low; the gas surrounding the target makes a significant contribution to the development of the plasma only at pressures above 40 atm. Figures 3; references 7: all Russian.
[25-6508]

UDC: 539.216.2:535.211

CALCULATION OF THERMAL DISTORTIONS OF A PICTURE DURING LASER TREATMENT OF THIN FILMS

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 5, Sep-Oct 80 pp 37-43
manuscript received 5 Mar 79

VEYKO, V. P., KRUTENKOVA, Ye. A. and KOTOV, G. A., Leningrad

[Abstract] Recently laser working of thin films has come into increasing use in the field of electronic and optical instrument construction for the production of pictures of thin film microcircuits, optical scales and other parts. Consideration of the substrate beneath the film greatly complicates mathematical investigation of the temperature field which arises during pulsed laser working of thin films. This work studies a method of solution of the three dimensional unsteady problem of heating of a system consisting of a thin film and a substrate exposed to short (10^{-7}-10^{-8} s) pulses of radiation to minimize the thermal distortion of the picture over a fairly broad range of dimensions ($\simeq 0.5\,\mu$m). The thermal distortion of rectangular elements is studied considering the contact between film and substrate to be ideal, the light flux density to be an exponential function of time and of the coordinates y and x (where the x coordinate is into the depth of the substrate). The temperature distribution in the film is determined by heat flow along the film through the side boundaries of the irradiated zone. The error in the calculated temperature in the thin film is determined by the different heat fluxes from the film into the substrate at the center and at the edge of the irradiated zone. The temperature field of the thin film was calculated in numerical form considering this variation in heat flux by solution of equations derived in this article on a computer. It was found that heat flux from the films into the substrate was significant even when thin films were treated with very short pulses. The complex temperature fields can be analyzed by calculating the distribution of temperatures in the plane of the film surface for an adiabatically isolated thin layer, considering the substrate by introduction of an amplitude coefficient determined by solving the one-dimensional problem. There is an optimal light flux density for which distortions of the dimensions of a rectangular element are prevented, while distortions of the shape are minimized. Shape distortions can be decreased further only by redistribution of the light flux density over the surface of the film. Figures 6; references 7: 5 Russian, 1 Czech, 1 Western.
[25-6508]

UDC: 621.762.4.04

HOT PRESSING OF TITANIUM CARBIDE-BASED HARD ALLOY

Kiev POROSHKOVAYA METALLURGIYA in Russian No 12, Dec 80 pp 32-34 manuscript received 24 Apr 80

KREPCHENKO, I. N., SIMKIN, E. S. and TSYPIN, N. V., Institute of Superhard Materials, Ukrainian Academy of Sciences

[Abstract] The authors' institute has studied the influence of hot pressing conditions on certain properties of titanium carbide-based hard alloy. The charge for molding the specimen was prepared by wet grinding in a ball mill of powdered titanium carbide, nickel and molybdenum. The mixing time was varied from 60 to 120 hr as a function of the granularity of the initial powder. The studies were performed with a charge containing the ingredients in the following relationship, mass %: TiC - 70; Ni - 24; Mo - 6. The charges were pressed in molds made of compact pure graphite with punches fitted to the dies. The inner surfaces of the dies were lubricated with colloidal graphite in water. The charges were heated by induction. The best physical and mechanical properties were obtained in hard alloys manufactured at 1723°K and 16 MPa. As the temperature increased, the coercive force of the hard alloy also increased, a result of a singularity of the mechanism of sintering of the alloys. The coercive force is inversely proportional to the grain size of the carbide phase. The titanium carbide grain size in this case depends essentially on the degree of dissolution of the molybdenum carbide in the grains of titanium carbide. As the quantity of dissolved molybdenum carbide increases, the structure of the titanium carbide becomes finer in grain. Consequently, as the hot pressing temperature increases, the solubility of molybdenum carbide in titanium carbide increases, thus decreasing the grain size of the titanium carbide. Figures 3; references 9: 8 Russian, 1 Western.
[22-6508]

UDC 669.71-174

THE EFFECT OF MULTIPLE STRENGTHENING-FINISHING TREATMENT ON THE PHYSICAL AND CHEMICAL STATE OF THE SURFACE LAYER

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian No 6, Nov-Dec 80 pp 105-106 manuscript received 19 Mar 79

KHVOROSTUKHIN, L. A., BELYKH, L. I. and KOVALEV, A. P., Moscow Aviation Technological Institute imeni K. E. Tsiolkovskiy

[Abstract] The effect of temperature and length of aging during heat treatment on the increase in weight of titanium alloy specimens was investigated to establish the principles of formation of the gas-saturated layer. The specific increase of weight of the specimens varies as a function of the temperature and aging time of VT3-1 titanium alloy specimens and shows a gradual decrease at all temperatures and times. The microhardness decreases throughout the layer of VT3 1 specimens after tempering at 860 and 920°C. The microhardness of the specimens increases after hardening at 860°C and diamond smoothing. Figures 4; references 3: all Russian.
[30-6521]

UDC: 669.017

MIGRATION OF THE BOUNDARIES OF β GRAINS IN TECHNICAL TITANIUM AND VT5 ALLOY

Ordzhonikidze IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: TSVETNAYA METALLURGIYA in Russian No 6, Nov-Dec 80 pp 73-76 manuscript received 23 Jul 79

KOLACHEV, B. A., SHEVCHENKO, V. V., Moscow Aviation Technological Institute, Department of Physical Metallurgy and Hot Working of Metals

[Abstract] Heating of titanium and its alloys above the Ac_3 point causes rapid growth of β grains. After the grains reach significant size, the sudden growth of grains is replaced by gradual migration of the boundaries of the β-phase grains. There is significant interest in direct observational data on the growth of grains during heating and isothermal holding of titanium. This work therefore presents results of high temperature analysis of technical titanium and the alloy VT5. An IMASH-5S-65 device was used to observe directly the changes in structure in the specimens at high temperatures. Sheet specimens 3 mm thick were used after polishing one face. The specimens were heated by transmission of electric current to temperatures of 900 to 1100°C, then held at the same temperature until visible changes in the structure stopped. At points below Ac_3 the grains were rounded in form and remained so. At temperatures above Ac_3 the rounded grains disappeared rapidly, and β grains with straight boundaries appeared. Then the β grain boundaries migrated. Time lapse photography was used to determine the migration rates of the boundaries at various temperatures. The maximum grain growth speed in titanium is $3 \cdot 10^{-2}$, $4 \cdot 10^{-2}$ and $7.6 \cdot 10^{-2}$ mm/min at 950, 1000 and 1030° C. Grain growth in all specimens during isothermal holding begins only

after a certain induction period has elapsed. The growth rate of the β grain first increases, then reaches a maximum, then finally decreases to 0 with isothermal holding. As the temperature rises, the maximum growth rate occurs earlier. Figures 3; references 5: all Russian.
[23-6508]

UDC: 669.295:621.178.385

FATIGUE STRENGTH OF TITANIUM AND THE ALLOYS AT3 AND AT6 AFTER OXIDATION

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 10, Oct 80 pp 45-47

BORISKINA, N. G., GUREVICH, S. Ye. and YEDIDOVICH, L. D.

[Abstract] A study is made of the influence of optimal oxidation (700° C, 50 hours) on the endurance of titanium and its alloys AT3 and AT6. Cylindrical specimens with a diameter of the gage portion of 6 mm were tested at room temperature in air at 2800 cycles per minute, test base $5 \cdot 10^7$ cycles. The fatigue durability and strength of the specimens in the initial state was the highest, thermal oxidation decreasing both durability and strength more than vacuum annealing. The tests allowed separation of the influence of the structure, which changes upon annealing, and the formation of a gas-saturated layer on the endurance of specimens. The increase in grain size in the titanium and the formation of additional quantities of intermetallic phases in AT3 after annealing at 700° C in a vacuum decreased the fatigue strength by 6-8 kgf/mm^2. The slight difference (2.5 kgf/mm^2) between the cyclical strength of AT6 in the initial and vacuum-annealed states can be explained by the greater thermal stability of the alpha solid layer of the alloy. The formation of a gas-saturated layer during annealing in air decreases the cyclical strength of all three materials. In air-annealed alloys the surface oxygen-saturated layer has higher brittleness and is therefore probably the focus of development of cracks. However, there is no direct dependence of the subsequent propagation of a fatigue crack on the depth of the surface oxidized layer. Figures 1; references 8: all Russian.
[24-6508]

UDC: 669.295:622.723

ANALYSIS OF THE PROCESS OF SORTING SPONGE TITANIUM

Moscow TSVETNYYE METALLY in Russian No 1, Jan 81 pp 93-94

SHIRYAYEV, R. Ye., LIKHTERMAN, V. A., SEMYANNIKOV, G. G., TSYPIN, Ye. F. and POPOVA, S. V.

[Abstract] Manual sorting of lumps of sponge titanium into the required diameter classifications is a cumbersome and nonproductive operation. Sorting is based on particle size and color according to State Standard GOST 17746-72. Since the smaller fraction (less than 12 mm in diameter) of lumps of sponge titanium is more difficult to sort manually on the basis of color, and contains more defective lumps to begin with, an automatic method of sorting the smaller fraction is especially needed. Studies have demonstrated the possibility of photometric sorting using the "sortex-621" machine. This article does not present a description of the process, but rather reports that other works have indicated that the process can sort out 80 to 90% of slime particles, 91.2-99.5% of oxidized particles, 70-80% of particles with iron and other elements, 100% of burned particles and 100% of other particles such as lumps of rubber from the transporter belt, etc. References 4: all Russian.
[33-6508]

UDC 621.791.72.011:669.245.018.44

CLASSIFICATION OF THERMALLY STABLE NICKEL ALLOYS BY WELDABILITY IN ELECTRON BEAM WELDING

Kiev AVTOMATICHESKAYA SVARKA in Russian No 12, Dec 80 pp 42-44 manuscript received 25 May 80

MOROCHKO, V. P., SOROKIN, L. I. and ZYBKO, I. Yu., Moscow

[Abstract] The dependence between the weldability of thermally stable alloys during electron beam welding and the tendency of these alloys to form hot cracks in the seam and in the zone near the seam during welding and heat treatment were investigated. The content of the titanium and aluminum strengthening agents and of the vanadium, cobalt, molybdenum, tungsten, niobium and iron alloying elements was varied. Reduction of the titanium and aluminum content or of aluminum content alone affects the increase in the resistance of the metal to crack formation. An increase in the thickness of the welded metal also affects the long-term strength of the joints. Cracks tend to form during heat treatment as the thickness of the welded metal increases and the long-term strength decreases. A titanium and aluminum content up to 2 percent results in good weldability of the alloys and this content is recommended for welded joints up to 30 mm thick with no restriction on the rate of welding. Figures 4; references 11: 7 Russian, 4 Western. [29-6521]

UDC 621.791.01:620.192.46

INCREASING THE TECHNOLOGICAL STRENGTH AND PLASTICITY OF WELDED INVAR COMPOUNDS AT LOW TEMPERATURES

Kiev AVTOMATICHESKAYA SVARKA in Russian No 12, Dec 80 pp 4-6 manuscript received 12 Feb 80

YUSHCHENKO, K. A. and STARUSHCHENKO, T. M., Institute of Electric Welding imeni Ye. O. Paton, Ukrainian SSR Academy of Sciences

[Abstract] The weldability of Invar 12 mm thick and the possibility of increasing the technological strength of welds by complex alloying were investigated. The seam metal varies as a function of the amount of silicon and manganese in the flux. Manganese, molybdenum and tungsten strengthen interatomic bonds upon being dissolved in the solid nickel-chromium solution and the activation energy of the

recently diffusion is enhanced. The plasticity of the seam metal can be increased at low temperatures if it is alloyed with a combination of metals. The critical rate of deformation varies as a function of molybdenum and molybdenum-chrome content in the seam. The use of [illegible] electrode wire in combination with AN-26 flux produces seams of equivalent strength with the base metal during argon-arc and contact welding and the seams are flexible and resistant to formation of hot cracks. Figures 3; references 6: all Russian.
[TS-4765]

THE ROLE OF THE STRUCTURAL FACTORS OF TITANIUM ALLOYS IN DIFFUSION WELDING WITH LIMITED DEFORMATION

Kiev AVTOMATICHESKAYA SVARKA in Russian No 12, Dec 56 pp 15-26, 29 manuscript received 5 Apr 56

[illegible], V. N., [illegible], V. V., [illegible], S. G. and [illegible], V. I., Voronezh and Moscow

[Abstract] The technology of welding titanium alloys with low residual deformation was investigated on forged bars and welded packets up to 11.3 cm in diameter and up to 30 cm high. The rate of creep in the welded specimens can be varied by regulating the initial structure. Thin-walled structures of titanium alloys can be joined by diffusion welding without loss of stability of the components by directed regulation of the structural state. Blank structures produced by deformation and isothermal structures produced during diffusion welding, welding in a vacuum and explosion welding of thin sheets of titanium alloys are most effective. Figures 6, references 5: all Russian.
[Abstract]

UDC: 537.226;537.311.322

LUMINESCENCE CENTERS IN ALLOYED ZnSe AND THE ACTIVATION ENERGY OF THEIR FORMATION

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 16, No 11, Nov 80 pp 1916-1920 manuscript received 11 Jun 79

KUKK, P. L. and PALMRE, V. V.

[Abstract] The quasi-chemical reactions of defect formation in alloyed zinc selenide are studied and their activation energy determined. The material used was zinc selenide which meets the requirements of ETO 035.011 TU, containing 10^{-4} mass % of primary alloying metal impurities, with an untested quantity of chlorine and oxygen. The material was purified in a current of H_2Se at 850° C to remove the chlorine and oxygen. The purified zinc selenide was then alloyed with copper or copper and indium from an aqueous solution of the corresponding nitrates in a current of H_2Se. The alloyed material was heat treated at 1000° C under a pressure of 10^{-3} mm Hg in sealed quartz ampules to achieve thermodynamic equilibrium of the defects, then either instantly cooled to 20° C to freeze the atomic defects or slowly cooled (over about 30 days) to achieve the equilibrium concentration of defects at low temperatures. They were then annealed in a special tubular furnace allowing rapid temperature rise and fall to 100-600°C and the spectral distribution of luminescence intensity was measured at 77°K. The nature of the defects responsible for the luminescence of ZnSe alloyed with copper, indium and chlorine is established. The activation energies of diffusion of interstitial copper (0.40±0.05 eV) of copper by the vacancy mechanism in the zinc sublattice (0.76±0.08 eV), and of doubly charged selenium vacancies (0.47±0.07 eV) in ZnSe are established. The activation energy of dissolution of indium in zinc selenide is 0.96±0.06 eV, that of liberation of Cu_2Se from the crystalline lattice of zinc selenide is 1.3±0.2 eV. Figures 3; references 8: 4 Russian, 4 Western. [16-6508]

UDC: 549.07+549.321.13+548.05

SYNTHESIS OF ZINC AND CADMIUM SULFIDES AND THEIR COCRYSTALLIZATION UNDER HYDROTHERMAL CONDITIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 16, No 11, Nov 80 pp 1912-1915 manuscript received 14 Feb 79

SAMOYLOVICH, L. A. and KLIYENTOVA, G. P., All-Union Scientific Research Institute for the Synthesis of Mineral Raw Materials

[Abstract] The hydrothermal temperature drop method was used to study the specifics of the transfer and crystallization of Zn and Cd sulfides when simultaneously present in solution. The experiments were performed at 250-300° C and $\sim 5 \cdot 10^7$ Pa pressure in the systems Zn-Cd-S-R and ZnS-CdS-R, where R are aqueous solutions of HCl, HF, HNO_3, H_3PO_4, NaOH and KOH. The experiments were performed in teflon-lined vessels of 150-250 cm^3. The crystallization chamber was separated from the dissolution chamber by a perforated diaphragm which controlled the temperature drop between the chambers. The experiments lasted 20 to 80 days. Two processes occurred: synthesis of sulfides at the location of the initial components and the transfer of matter in the form of complex compounds into the low-temperature area with liberation of new phases. The experiments showed that phase formation in hydrothermal solutions depends essentially on the composition of the mineralizer and the quantitative relationships of the components. The cation-anion composition of the solutions also influences the structural type of sulfides produced in the systems studied. The hexagonal modification of mixed crystals (Zn, Cd) S is more easily formed in an acid solution with predominance of Cd over Zn. The cubic modification is produced primarily in alkaline media. With low Cl^- activities and excess Zn in the system, the cubic modification may appear in hydrochloric acid solutions. References 10: 9 Russian, 1 Western.
[36-6508]

UDC 536.422.1

AUTO-OSCILLATIONS DURING THE EFFECT OF CONCENTRATED ENERGY SOURCES ON MATTER

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 6, Nov-Dec 80 pp 3-7 manuscript received 8 Jul 80

ZUYEV, I. V., SELISHCHEV, S. V. and SKOBELKIN, V. I., Moscow

[Abstract] Auto-oscillations were studied theoretically in the range of 10 to 10^3 hertz in the matter-vapor-beam system when the surface was shielded from the beam by a vapor of the substance being evaporated. A series of equations is derived to describe the kinetics of the process. The results can be applied to energy sources in which the beam interacts with the vapor of the substance being evaporated. Figures 1; references 9: all Russian.
[28-6521]

UDC: 546:669.295.24

SYNTHESIS OF CAST TITANIUM NICKELIDE BY COMBUSTION PROCESSES

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 16, No 11, Nov 80 pp 1957-1960 manuscript received 3 Oct 79

ITIN, V. I., KHACHIN, V. N., BRATCHIKOV, A. D., GYUNTER, V. E. and CHERNOV, D. B., Siberian Institute of Physics and Technology imeni V. D. Kuznetsov

[Abstract] Data are presented on the properties, structure and phase composition of cast specimens of titanium nickelide manufactured by the combustion method - the method of spontaneously propagating high-temperature synthesis. Powders of nickel and titanium were dried in a vacuum oven at 60-70° C for 6-8 hours, then mixed dry for 8 to 10 hours; cylindrical specimens 2-3 cm in diameter with initial porosity of about 40% were pressed from the powders and synthesis was performed in a constant pressure vessel. The adiabatic temperature of interaction of the components is 1270° C, slightly above the melting point of titanium nickelide, so that the combustion method should provide liquid titanium nickelide. Actually, both upon combustion and upon thermal explosion, the cast products are formed by a solution of the solid components in the initial melt formed on the surfaces of the components, and subsequent crystallization. The phase composition of the products produced is therefore practically the same. X-ray analysis shows that the ingot produced in either case consists practically completely of the phase TiNi, plus traces of Ti_2Ni. Specimens were poured in graphite crucibles, heated to 800° C in argon, then rolled in air to a thickness of 1 mm. Metallographic and electron-microscopic analysis showed large numbers of dispersed particles of the unclear composition and crystalline structure, probably Ti_4Ni_2O (N, C). The mechanical properties were determined at -196° C and +150°C:

	-196°C	150°C
$\sigma_{0.1}$, Pa	$34 \cdot 10^7$	$48 \cdot 10^7$
σ_b, Pa	$98 \cdot 10^7$	$99 \cdot 10^7$
δ, %	23	18

Figures 1; references 7: 6 Russian, 1 Western.
[36-6508]

UDC: 669.715-419

TECHNOLOGY OF PRODUCTION OF BIMETALLIC STEEL-AMts ALLOY SHEETS FOR CRYOGENIC VESSELS

Moscow TSVETNYYE METALLY in Russian No 1, Jan 81 pp 66-67

LUKASHKIN, N. D., MIKLASHEVICH, Ye. M., KONDAKOV, B. P. and KRUPITKINA, T. Ye.

[Abstract] A description is presented of a technology of manufacture of bimetallic sheets by joint plastic deformation of AMts aluminum alloy sheets and steel (type 12Kh18N10T stainless) sheets assembled in packets consisting of two aluminum sheets with two steel sheets between the aluminum sheets. The aluminum alloy was degreased by etching in NaOH at 50° C with washing in 15-20% HNO_3; the steel sheets were degreased in a solution of sodium phosphate, sodium hydroxide and sodium silicate at 70-90°C with subsequent washing in water and etching in HNO_3. The degreased surfaces were then roughened with wire brushes, assembled and hot rolled with a total of 35-40% deformation (8-12% per pass), producing bimetallic sheets with good adhesion between layers and good working properties. The bimetallic sheets produced had a tensile strength of at least 320 MPa, $\delta \leq 16\%$, sheet thickness 3.5 mm, steel thickness 1-1.5 mm. The sheets are widely used for the manufacture of Dewar flasks. A cross-sectional diagram of such a flask is presented. Annealing of scraps at 530-570°C causes separation of the layers so that the aluminum and steel can be reused.
[33-6508]

UDC: 533.9

PLASMA METALLIZATION OF POWDERS

Moscow FIZIKA I KHIMIYA OBRABOTKI MATERIALOV in Russian No 5, Sep-Oct 80 pp 48-52 manuscript received 17 Mar 80

PETRUNICHEV, V. A. and SMIRNOV, A. I., Moscow

[Abstract] A study is presented of a plasma process of production of clad powders with spherical particle shape developed at the Institute of Metallurgy imeni A. A. Baykov, USSR Academy of Sciences. The example discussed is a system consisting of aluminum oxide and nickel, used in the development of cermets. Experiments were performed on an installation with a multisectioned plasmatron with a power rating of 100 kW, a sealed experimental chamber and a 2-chamber feeder tank to feed the powder to the plasma in the suspended state. Argon was used as the plasma-forming and powder-transforming gas. The plasma jet was 170 mm in length and 15 mm in diameter; temperature was 10,500°K, axial velocity 120 m/s (both near the nozzle), and temperature at the other end of the jet 1600-3500°C. The aluminum oxide powder was the alpha modification, particle diameter 50 μm, the nickel particles being not over 5 μm in diameter. Magnetic separation was used to estimate the effectiveness of metallization of the particles. Earlier experiments indicated that if aluminum oxide particles up to 50 μm in diameter are maintained in a plasma for about 10^{-3} s, they will melt and become spherical,

while nickel particles of the diameter used should evaporate completely. After the initial experiments, the particle diameter was reduced to not over 40 μ m, and nitrogen was added to the argon atmosphere, achieving a yield of spherical particles of up to 95-97%. Photomicrographs are presented of the resulting particles, a cross section of the particle and a section of metal-ceramic material with metallized granules. The clad refractory granules have excellent adhesion characteristics. Figures 5; references 12: 11 Russian, 1 Western.
[25-6508]

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